SCOTT, COX & ASSOCIATES, INC. consulting engineers • surveyors

July 25, 2013

Neil and Rose Dykes
C/o Jonathon Werner
Creative West Architect
PO Box 18261
Boulder, CO 80308

Project: 13299S

Ladies and Gentlemen:

Enclosed with this letter are three copies of the Subsurface Investigation Report for the proposed new structure and pavement to be constructed at 1617 and 1625 Lincoln Place in Boulder, Colorado.

If there are any questions regarding our investigation or the report, please do not hesitate to contact us.

Sincerely,

SCOTT, COX & ASSOCIATES, INC.

By Kevin L. Hinds

Kevin L. Hinds, P.E.

Enclosures

Project 13299S

SUBSURFACE INVESTIGATION

Proposed New Structure and Pavement
1617 and 1625 Lincoln Place
Boulder, Colorado

Prepared For:

Neil and Rose Dykes
C/o Jonathon Werner
Creative West Architect
PO Box 18261
Boulder, CO 80308

July 2013

Prepared By:

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1530 55th Street
Boulder, Colorado 80303
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Table of Contents
Project 13299S

SUBSURFACE INVESTIGATION
PROPOSED NEW STRUCTURE AND PAVEMENT
1617 AND 1625 LINCOLN PLACE
BOULDER, COLORADO

PURPOSE

This report presents the results of a subsurface investigation performed July 12, 2013, for the proposed new structure and pavement to be constructed at 1617 and 1625 Lincoln Place in Boulder, Colorado. This investigation was made to provide design criteria for the foundation system of the new structure and pavement to be located on this site. Two (2) borings were completed during the course of this investigation, in or adjacent to the proposed new building envelope and where accessible with a truck mounted drilling rig. The locations of the borings are indicated on the Boring Location Map (Figure 1).

Factual data gathered during the field and laboratory work is summarized in Figure 2 and Table 1 attached. The results of this investigation, our opinions that are based on this investigation, and our experience in the general area, are summarized in this report.

INVESTIGATION DETAILS

The field investigation consisted of drilling one (1) deep foundation related boring in the area of the proposed structure and one (1) shallow boring in the area of the proposed pavement as outlined below. The borings were completed with 4-inch diameter, continuous flight power augers using a truck mounted drill rig.

The augers are utilized to bore and clean the hole to the desired sampling depth. The augers are then removed, and a 2-inch I.D. California spoon sampler is inserted to the desired testing depth. The sampler is then driven with blows of a standard 140-pound hammer falling a distance of 30 inches.

The sampler is driven a total of 12 inches or a maximum of 50 blows. The number of blows required to drive the sampler 12 inches, or a fraction thereof, constitutes the penetration test. The test is similar to the Standard Penetration Test described in ASTM D1586. This test, when properly evaluated, is a measure of the soil strength and density. The results of these tests are shown on the Graphic Boring Logs (Figure 2). Bulk auger samples were taken from the pavement related boring.

All soil samples recovered were inspected, and some samples were selected for testing by the project engineer. Limited laboratory testing was performed due to the available samples. The testing program consisted of performing the following tests where appropriate:

Consolidation/Swell

- Consolidation/Swell tests were performed to determine the relative stability of the different subsurface soil types.

Natural Dry Density

- The dry density of the soils provides us with an indication of the relative compaction of the surficial soils.

Natural Moisture Content

- The moisture content test provides us with information, which may indicate the probability of instability due to consolidation or swell that, may be caused by excessive wetting or drying.

Unconfined Compressive Strength

- The approximate unconfined compressive strength was determined by use of a calibrated hand penetrometer. The unconfined compressive strength can be useful in determining the bearing capacity of a soil.

PROPOSED DEVELOPMENT

As currently planned, the existing structures are to remain and a new 2-unit structure is to be constructed. The new structure will be one to two-stories, constructed using conventional wood framing techniques and will be supported by poured-in-place reinforced concrete foundation walls. The structure will be constructed over a basement or crawl space. The loadings are anticipated to be light to moderate with no unusual loading conditions.

If actual building plans differ from the above description, we should be notified so that our recommendations can be reviewed and revised, if necessary.

SITE CONDITIONS

At the time of our investigation, the lots contained existing residences and garage within an older-developed subdivision. Existing residences and structures are located on all sides with Lincoln Place to the east. The ground surface generally sloped down the northeast. Vegetation on the site consisted of a sparse to heavy growth of grass along with some large trees and shrubs.

SUBSOILS

The borings encountered a 5-foot thick layer of very silty, sand and clay fill material at the surface. Dark brown to black, very silty, sand and clay (possible fill) was encountered beneath the fill in the foundation related boring and extended to a depth of approximately 12 feet. A brown, silty, sand and gravel was encountered in the deeper boring at a depth of approximately 12 feet and extended to a depth of approximately 32 feet. Gray, silty, sandy claystone was encountered beneath the surficial soils in the deeper boring and continued to the bottom of the boring, approximately 34 feet beneath the existing grade.

A detailed description of the soils encountered in this investigation is presented in the Graphic Boring Log (Figure 2).

GROUNDWATER CONDITIONS

Groundwater was encountered in the foundation boring at the time of drilling and when checked subsequent to drilling was encountered at a depth of approximately 5 feet below the existing ground surface. While we are nearing the time of the seasonal high groundwater table, some rise of the groundwater table must be anticipated. It is not possible to forecast the seasonal high groundwater table based on short duration monitoring. The only sure method of such determination is monitoring of the water table through the spring and early summer (typical seasonal high groundwater levels occur about July1). We recommend that the bottom of any excavation be maintained a minimum of 3 feet above the seasonal high groundwater table. There is also a potential for a future "perched" groundwater table as discussed further in the "Site Drainage Considerations" section of this report. Any ditches, streams or other water features can influence the depth to groundwater at the site.

FOUNDATION RECOMMENDATIONS

The existing fill is not considered suitable to support any foundation loadings. The clays and dark brown to black, very silty, sand and clay (possible fill) encountered in the borings, are considered to be of low expansion potential and also relatively weak and consolidation prone when loaded. The sand and gravel is considered to be of very low expansive potential. The claystone is considered to be of high expansion potential. Outlined below are two potential foundation types which could be utilized at the site.

Drilled Piers

The safest foundation type for the site would be drilled piers. The piers should be designed for an end bearing of 20,000 PSF and side shear of 2,000 PSF, based on bedrock embedments of greater than 2 feet. The design pressures should be based on the dead load plus 100% of the maximum anticipated live load. No minimum dead load is required since the pier analysis has been done assuming a minimum dead load condition.

The piers should be designed for a minimum bedrock embedment of 10 feet. In addition, we recommend that a minimum pier length of 22 feet be maintained under all circumstances. The minimum embedment lengths should be taken below any weathered portions of the bedrock.

The piers should be reinforced with a minimum of three #5 bars (grade 60 or equivalent reinforcement, assuming 10 inch diameter piers) for their full length. A 4-inch minimum void space should be provided beneath the grade beams to assure effective concentration of the loads upon the piers. The grade beams should be centered upon the piers, and the tops of the piers should not be enlarged. The grade beams spanning the piers should be designed for appropriate loading conditions and reinforced accordingly.

In our opinion, casing will probably be required during drilling of most of the piers for the site. The concrete should be placed in the pier holes immediately after drilling, a thorough cleaning and inspection. In no case should concrete be poured with more than 4 inches of water present in the holes. The use of a concrete pump truck may be necessary if water cannot be sealed off. Also, a larger than normal pier drilling rig will be necessary due to the depth to bedrock and required penetration.

Footings

Due to the upper level fills and relatively weak soils at the site, footings are generally not considered appropriate for this site. However, it may be possible to utilize footings with appropriate soil remediation. Remediation may consist of removing the weak soils (approximately 12 feet thick) and placing back a rock blanket to transmit the loads down to the sand and gravel soils. Such remediation would need to be determined at the time of excavation and may require additional testing. Also, excavations will be below the existing groundwater table which will require extensive dewatering. With the considerations outlined above the structures could possibly be supported on spread footings, either continuous spread footings or isolated pad footings, founded on the replaced, rock blanket, utilizing a uniform soil bearing pressure not to exceed 1,500 PSF. The loading should be based on the dead load plus 100% of the maximum anticipated live load.

Differential settlement must be considered in the design of the foundation system. Differential settlement should be kept to a minimum, which can be achieved by keeping loads as uniform as possible throughout the foundation elements.

Foundation walls supported by footings should be designed as grade beams capable of spanning a minimum distance of 12 feet. The amount of reinforcing steel used should not be less than two No. 5 bars, both top and bottom of the foundation wall. Reinforcement should be continuous around corners. Differential settlement will be minimized by proper reinforcement of foundation walls.

The footings lines should be carefully inspected by an engineer from our office prior to placement of the footings. Any areas of soft or loose soils or unsuitable soils, which are present at the proposed footing level, should be removed down to satisfactory, undisturbed soil. Footings can then be placed directly upon the native undisturbed soils or the excavation can be backfilled to the desired footing elevation with compacted, select granular fill placed in lifts not to exceed 9 inches in thickness and compacted to a minimum of 100% of maximum density as determined by the moisture/density relationship ASTM D698.

SLABS-ON-GRADE

Most of the soils anticipated to be beneath the slabs-on-grade will have a low expansive potential. Therefore, some slab movement is anticipated if the soils beneath the slab become wetted. The possibility for wetting can be mitigated by following the site drainage recommendations presented in this report. However, it is probable that some slab damage (such as cracking and heaving) will take place if slab-on-grade construction is utilized.

The actual amount of possible slab heave is very subjective due to variability in the soils resulting in variability in expansion and also the degree and depth of wetting beneath the slabs. Outlined below is a prediction of the possible slab movements for the general soils at this site based upon a typical maximum wetting depths of five feet, which is an average worse case scenario. There were typically three different soil types at the site, which could influence the slabs-on-grade. The first soil type being a silty, sand and clay fill material which cannot be predicted due to its highly variable characteristic. The second soil type being low expansive very silty, sand and clay, and the second type being very low expansive sand and gravel.

Sand and Clay, (Low expansion potential)
    Approximately ½ to 1½ inches
Sand and Gravel, (Very Low expansion potential)
    Approximately ½ inches

It should be noted that these potential movements are only a prediction based upon the soils tested and typical slab movements seen from similar soils and wetting conditions.

There are typically four different slab-on-grade scenarios on typical residential construction. These are interior slabs in living spaces, garage slabs, patios (and stoops) and other exterior concrete like the driveway and sidewalks. We will discuss these in separate sections, below…

Interior Living Spaces

There are basically three different scenarios for floor slab construction at the site. They are as follows from least expensive with most risk of potential movement to most expensive with least risk of movement.

1. Place slabs-on-grade on existing site soils with limited subgrade preparation. The owner should be aware that some slab damage is likely to occur.

2. Remove and replace a portion of existing expansive soils with a non-expansive granular fill soil. This will buffer the slabs from localized heave or settlement to an extent, but some slab damage is still likely to occur. Attached to this report, Appendix A, is a discussion of the risk reduction with different depths of removal and replacement.

3. Utilize structural floor system which would isolate it from the existing site soils.

Garage Floor Slab

Standard practice in this area is to found the garage slab on native soils, with a small depth of moisture treatment (soils compacted to a relatively high moisture content). It has become common for the garage area to be dug out to the foundation level, the foundation installed and the foundation walls constructed, with the area inside the garage space filled with compacted soils. This results in a depth of fill below the garage slab of 3 feet or greater.

As such, there are three options for the garage slab, as follows…

1. Fill the garage with moisture stabilized native soils. Since this is a confined space and sealed by a concrete slab, we believe that this option can be considered. This will buffer the slabs from localized heave or settlement to an extent, but some slab damage is still likely to occur.

Attached to this report, Appendix A, is a discussion of the risk reduction with different depths of removal and replacement, which we consider to be applicable to moisture stabilized native soils at this site.

The fill should be compacted in maximum 9 inch lifts at 0 to +3% from optimum moisture content and compacted to a minimum of 95% of maximum density as determined by the standard moisture/density relationship test ASTM D698 (commonly called a standard proctor test).

2. Remove and replace portion of existing expansive soils with a non-expansive granular fill soil. This will buffer the slabs from localized heave or settlement to an extent, but some slab damage is still likely to occur. Attached to this report, Appendix A, is a discussion of the risk reduction with different depths of removal and replacement.

3. Utilize a structural floor system, which would isolate it from the existing site soils. While this is technically possible, it is very expensive due to the high slab loading due to the vehicular traffic and it is generally not done due to the high cost and the fact that some slab movement in the garage is generally tolerable.

We consider options 1 and 2 to be approximately equivalent in risk of floor slab movement and either of these options would be better than standard practice in the industry. It is our understanding that one of these options will be used to a depth of 3 to 4 feet.

<u>Patios and Stoops</u>

Standard practice in this area is to found patios and stoops on native soils, with a small depth of moisture treatment (soils compacted to a relatively high moisture content) or designing them as structurally supported slabs on drilled piers or on haunches support by the adjacent foundation walls (primarily for stoops).

As such, it is our opinion that there are two options for these slabs, as follows...

1. Remove some thickness of the native soils and replace them with moisture stabilized native soils. There is a slightly greater risk of movement due to shink and swell of these soils with seasonal variations of the moisture content of the soils supporting the slab. This process will buffer the slabs from localized heave or settlement to an extent, but some slab damage is still likely to occur. Attached to this report, Appendix A, is a discussion of the risk reduction with different depths of removal and replacement,

which we consider to be applicable to moisture stabilized native soils at this site.

The fill should be compacted in maximum 9 inch lifts at 0 to +3% from optimum moisture content and compacted to a minimum of 95% of maximum density as determined by the standard moisture/density relationship test ASTM D698 (commonly called a standard proctor test).

2. Utilize structural floor system, which would isolate it from the existing site soils.

Driveway and Other Exterior Slabs

Standard practice in this area is to found driveways and other exterior slabs on native soils, with a small depth of moisture treatment (soils compacted to a relatively high moisture content). This has generally been acceptable, with, overall, a relatively small percentage of the slabs requiring replacement.

General Considerations

If slabs-on-grade supported by soil are utilized (native, moisture stabilized native or replaced with non-expansive materials), the following construction techniques will help to prevent secondary damage that could be caused by slab movement.

1. Separate slabs from the foundation elements with a slip joint. One method of doing this is to use two layers of tempered hardboard with a silicone lubricant between the boards. A slip joint should be used around the perimeter of the slab and adjacent to any other structural elements.

2. Moderately reinforce slabs with reinforcement continuous through interior slab joints. Slab joints must be provided to control the cracking. The floor joint grid should be designed to allow no more than 150 square feet of continuous slab.

3. Any load bearing partitions must be provided with their own foundation system and the slab separated as outlined above.

4. Provide a 1½-inch minimum air space below any interior non-load bearing partition. It should be noted that we have seen slab movements in this area in excess of 1½ inches, which have typically been caused by poor surface drainage causing seepage into the backfill and then into the soils supporting the slabs. In our opinion, 1½ inches should be adequate as long as the surface drainage is properly maintained and controlled. Slab movements should be monitored so that the slab is not allowed to exert

pressure on the bottom plate of non-load bearing partitions. If the slab moves within ¼ inch of the bottom plate, additional void space will have to be provided.

If unsure of the proper construction methods to achieve the recommended air space we should be contacted for further recommendations.

5. Any pipes rising through the slab should be provided with flexible couplings or other means to allow substantial movement without damage to the piping. Any ducts connecting to equipment founded on the slab should be equipped with flexible or crushable connections to allow for some slab movement.

6. Equipment and other building appurtenances constructed on the slab should be constructed so that slab movement will not cause damage.

Following the recommendations given above will not prevent movement of the floor slabs in the event that the moisture content of the soil beneath the slab changes. However, if movement occurs, the damage may have been reduced for a relatively small investment.

Prior to pouring a slab it is essential that all debris, topsoil and organic materials be removed. The slab subgrade soils should then be prepared and compacted utilizing the recommendations presented in the previous sections. It should be noted that failure to provide adequate fill compaction can result in settlement, which may cause slab damage such as cracking and tilting.

SITE DRAINAGE CONSIDERATIONS

Site grading must be provided to prevent infiltration of surface water into the foundation system. The following methods of preventing this infiltration are recommended:

1. Mechanically compact all fill around the building, including the backfill. Compaction by ponding or saturation must not be permitted. The backfill should be compacted to not less than 90% of maximum density as determined by the standard moisture/density relationship ASTM D698. Backfill, which is to support slabs, should be compacted to 95% of maximum dry density. Note that some moisture may need to be added to the soils in order to obtain the proper compaction.

2. Provide an adequate grade for rapid runoff of surface water away from the structure (a minimum of 10% for the first 10 feet away from the structure is recommended, 2% if paved).

3. A well constructed, leak-resistant series of gutters, or other roof drainage system, is essential.

4. Discharge roof downspouts and all other water collection systems well beyond the limits of the backfill, a minimum of 5 feet.

5. Observe and comply with any other precautions which may be indicated during design and construction.

It is our opinion that perimeter drainage systems should be installed at this site for any area which is below grade. The perimeter drainage system should consist of 4-inch perforated pipe, surrounded by a ¾ inch to 1½ inch washed rock. The drains should be placed a minimum of 12 inches below the surface of the adjacent concrete slab or bottom of the grade beam and should drain to a positive gravity discharge (surface discharge strongly recommended) or to a sump from which water can be pumped. Attached to this report are illustrations of suggested perimeter drain details (Figures 3 and 4). If the excavations are to extend to within 3-feet of the seasonal high groundwater level, then a more extensive and expensive system will be necessary (refer to Figures 5 and 6). We are available to provide appropriate recommendations.

EARTH RETAINING STRUCTURES

At this site we recommend that the walls be designed using a lateral earth pressure equivalent to that developed by a fluid weighing 45 pcf plus any additional surcharge loads. Use of this value assumes that the wall will be backfilled with the site soils and that these soils will not be allowed to become saturated at any time during the life of the wall. Saturation can be prevented by proper site grading and drainage and installation of drainage systems at the base of any walls that are to retain soil above grade.

This value is valid for walls up to 10 feet in height.

PAVEMENT INVESTIGATION

The silty, sand and clay soils anticipated to be beneath pavements are of low to moderate strength and are moisture sensitive. They are also fill materials of unknown placement and compaction. A representative sample was classified by laboratory analysis. The result is presented below.

Boring No.	Unified Classification	AASHTO Classification
P-1	SM	A-2-4 (0)

Testing has indicated that an "R" value of 5 is appropriate for use at this site for the subgrade soils.

For the purpose of this report, we are presenting two different pavement sections; one for light traffic use for the parking and the other for heavy traffic loadings which will be subject to semi-trucks, delivery trucks/vans and garbage trucks. We have used an 18 KIP EDLA value of 5 for the parking areas and an 18 KIP EDLA value of 20 for the heavy truck use. These values should be confirmed when traffic studies are completed.

A design ESAL of 36,500 (EDLA of 5) is used for car and light truck parking and a design ESAL of 146,000 (EDLA of 20) is used for travelways and truck access. Therefore, the design parameters are as shown on the table below.

	Car & Light Truck Parking	Travelways & Truck Access
ESAL	36,500	146,000
Reliability	80.00	80.00
Overall Deviation	0.440	0.440
Resilient modulus of subgrade	3,025	3,025
PSI Loss due to traffic	2.500	2.500

Utilizing the CDOH flexible pavement computer design program, we obtained a design structural number of 2.55 for the car and light truck parking and a design structural number of 3.13 for travelways and truck access. These values are the basis for the design calculations.

Groundwater was encountered during our investigation at depths of greater than 5 feet. It is our opinion that groundwater will not be a factor in the pavement design, provided no major cuts are planned at this site.

Following are the pavement sections recommendations:

<u>Car and Light Truck Parking Only</u>

Alternative 1	3.0" Asphaltic Concrete over 9.0" Aggregate Base Course (Class 6)
Alternative 2	6.0" Full Depth Asphaltic Concrete
Alternative 3	6.0" Portland Cement concrete

Travelways and Truck Access

Alternative 1	4.0" Asphaltic Concrete over 10.0" Aggregate Base Course (Class 6)
Alternative 2	7.5" Full Depth Asphaltic Concrete
Alternative 3	7.0 " Portland Cement Concrete

Additionally, we recommend that areas that are subject to loadings such as trash truck stopping, turning, and off-loading dumpsters be designed with concrete pads. The pads should be a minimum of 10 inches thick and reinforced with a minimum of #4 bars at 12 inch centers, both directions. The bars should be placed 3 inches above the bottom of the pad.

It should be noted that this design is based on typical strength coefficients for road pavement materials being utilized in the area. The assumptions are as follows:

Material	Strength Coefficient (per inch)
Asphaltic concrete pavement	.43
Base Course	.14

The strength coefficients of the materials to be used in the construction should be obtained from the contractor supplying the materials. Adjustment in the pavement section should be made to reflect the actual strength of the materials being utilized.

Subgrade Preparation

It is important to note that successful implementation of any of the pavement sections assumes a properly prepared subgrade. In connection with subgrade preparation, we recommend that:

1. Topsoil, any organic materials and any debris should be stripped from all areas to be paved.

2. The subgrade soils should be brought to proper grade for the selected section.

3. The subgrade materials should be scarified to the minimum depth of 6 inches to a minimum of 95% of maximum dry density as determined by

the ASTM D698 specification. Further, any fills which are required should utilize, if available, on-site materials with a classification equal to or greater than the subgrade soils on which the design is based. Any fill material shall be subject to the approval of the geotechnical engineer. Compaction of any fill should be to the above requirements. When compaction of the subgrade is achieved, the pavement section should be placed on the compacted subgrade. We recommend that the base course be compacted to a minimum of 95% as determined by the modified moisture/density test ASTM D1557 and the asphalt compacted to a minimum of 95% as determined by the standard Marshall Test ASTM D1559.

Due to the relative moisture sensitivity of the on-site soils, it is extremely important that proper site grading and drainage by maintained on and around the areas to be paved. Water should not be allowed to pond on top of the pavement, and landscaping should not create negative drainage toward the edge of the paved area. Care should be taken so that landscaping which requires irrigation does not create adverse effects to the pavement.

It should also be noted that there are many alternative remedial treatments, such as lime stabilization and moisture conditioning that could add additional stability to the pavement areas, by making the subgrade soils less moisture sensitive. There are different cost considerations with each possible alternative. If you would like to discuss the alternatives, please contact us.

We recommend that all work be inspected by a qualified geotechnical engineer and that density tests be performed to assure that the required compaction is being obtained.

LIMITATIONS

The borings in this investigation are believed to present a reasonably accurate knowledge of the existing subsoils. However, variations of subsoils not indicated by the borings are always possible. Therefore, we recommend that all excavations be inspected by an engineer from our office to confirm that the soils actually are as indicated by the investigation and to make recommendations if differences are noted.

It should be noted that the foundation system recommendations in this report are in accordance with the normal standard of practice assuming that the drainage recommendations provided in this report are strictly adhered to. If the soil supporting the foundation becomes wetted over a substantial period of time due to poor grading and drainage (or any other cause) , it is very possible that there could be damage to the foundation system and the slabs-on-grade. It is impractical to design a foundation system on expansive clay soils where poor site grading and drainage is allowed. In many areas along the front range expansive soil layers are relatively thick and when abnormally deep wetting occurs then typical foundation systems would not be adequate.

Identification of potential hazardous waste material, if any, at this site is beyond the scope of work for which the activities of this project were intended.

We would like to stress that it is not possible to fully determine the seasonal groundwater table fluctuations (and, therefore, the seasonal high groundwater table) with the short duration monitoring completed during the scope of this investigation. We have presented the method necessary to do such determination in the section titled "Groundwater Conditions". It is always possible that the groundwater table could rise to unanticipated levels, due to unknown or unrecognized groundwater sources. Unanticipated groundwater levels will also impact the recommendations, contained in this report, for the perimeter drainage system type and extent, which may be inappropriate for groundwater table levels that rise to unanticipated levels.

Due to the changing nature of geotechnical engineering practices, the information and recommendations provided in this report shall only be valid for two (2) years following the date of issue. After that time, our office should be contacted to review the information presented in this report and provide updated recommendations and design criteria appropriate for the engineering methodologies used in standard practice at that time.

INSPECTION AND QUALITY CONTROL

Placement of any significant thickness of fill, particularly fill that is to remain in place beneath loaded slabs or other structural elements, should be inspected and tested by a qualified soils engineer. We also recommend that the pier drilling, if utilized, and any excavations be inspected by an engineer from our office.

Sincerely,

COLORADO REGISTERED KEVIN L. HINDS 30243 PROFESSIONAL ENGINEER 7/25/13

SCOTT, COX & ASSOCIATES, INC.

By Kevin L. Hinds
Kevin L. Hinds, P.E.

Reviewed:

By
M. Edward Glassgow, P.E.

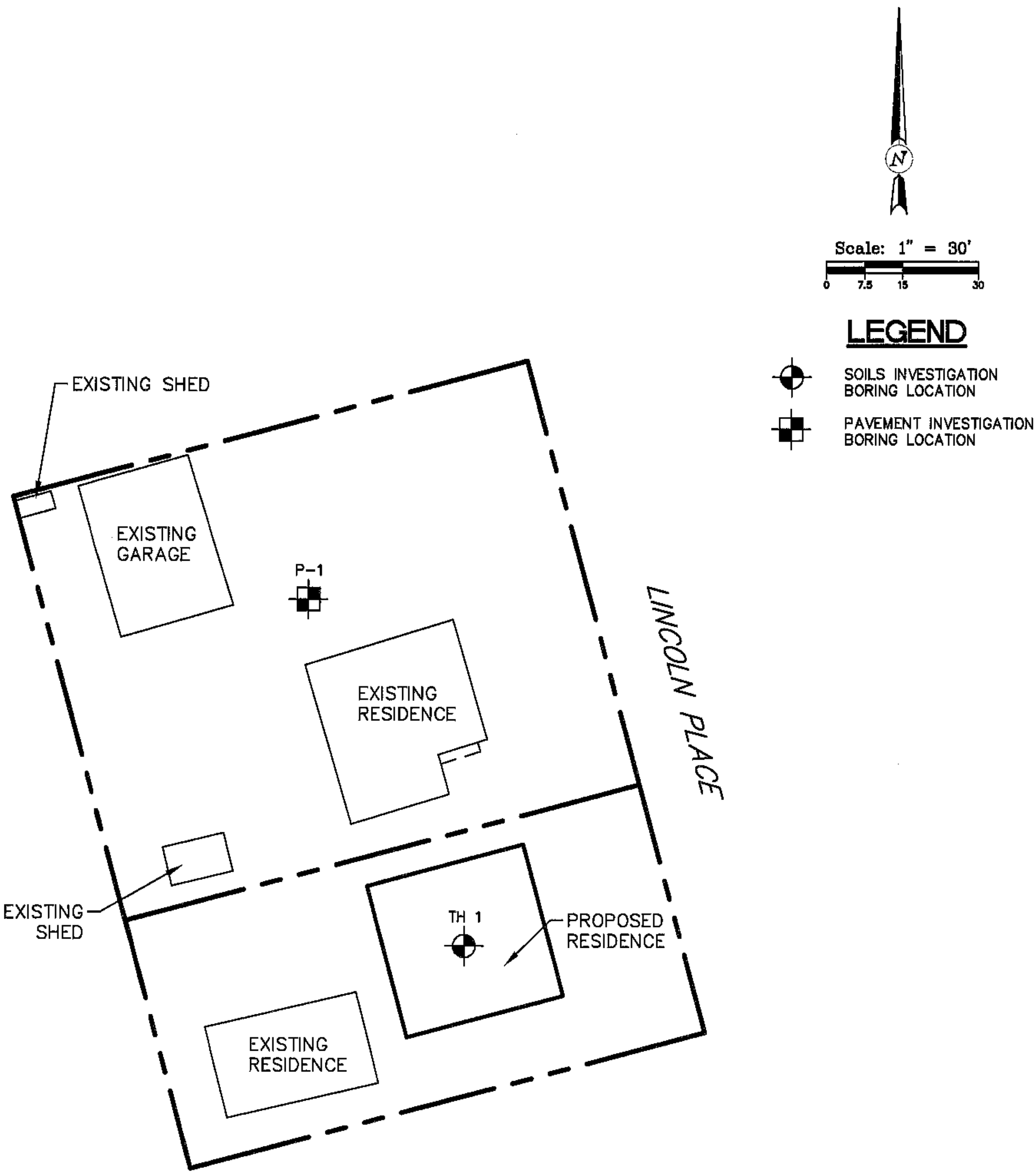

FIGURE 1
BORING LOCATION MAP

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7/18/13 JOB NO. 13299S DRAWING NO. 13299S

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Graphic Boring Logs

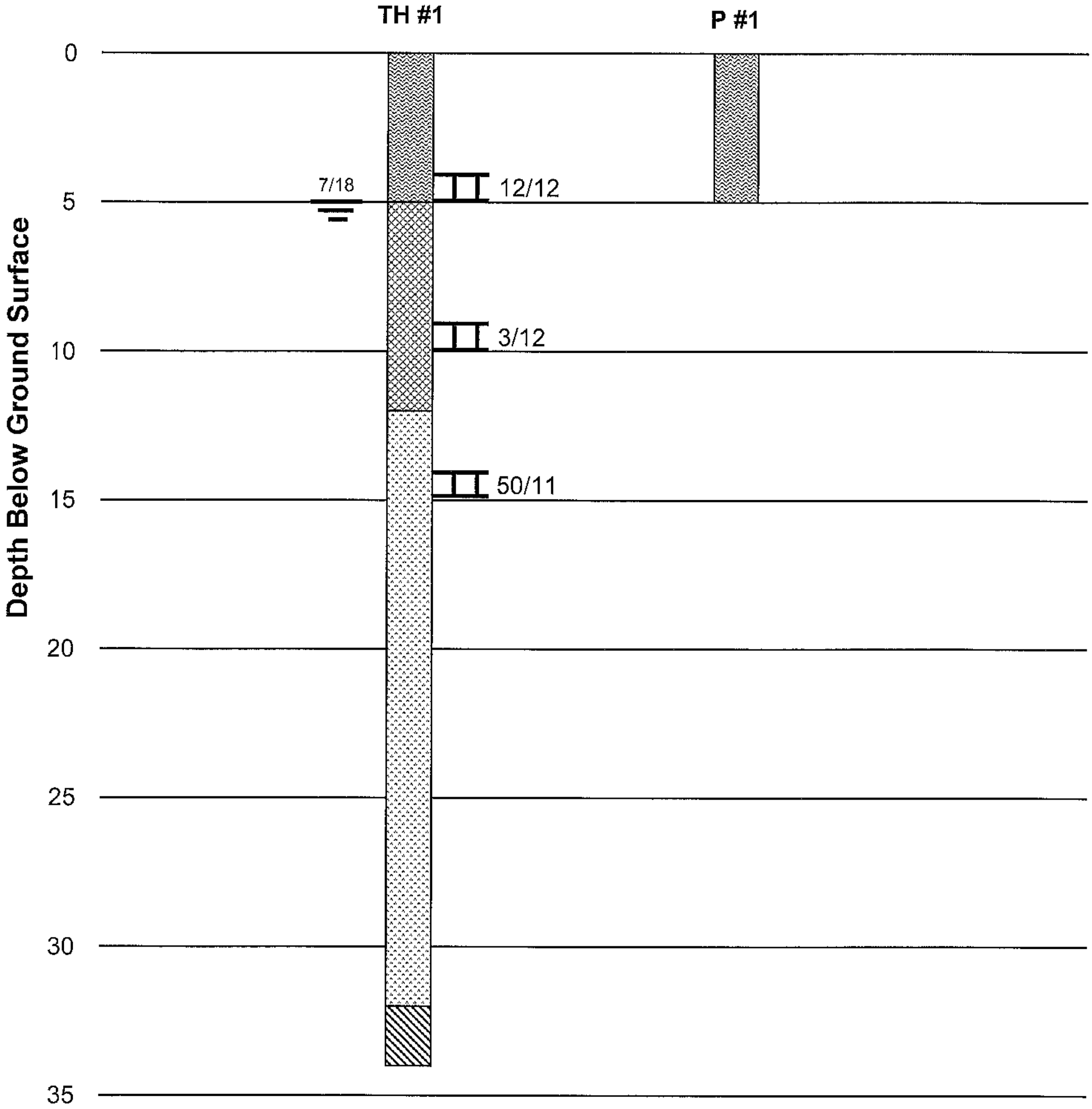

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Figure 2
Page 1

Project 13299S

Description of Soil Types

Fill - Mottled brown to Dark brown, very silty, sand and clay with some gravel, debris and organics

Dark brown to black, very silty, sand and clay - Contains some gravel and organics (possible fill)

Brown, silty, sand and gravel

Gray, silty, sandy claystone

TH #1 Soils investigation boring number

Indicates a change in soil type - May be gradual.

12/12 — 12/12 indicates that 12 blows of a 140-pound hammer falling 30 inches were required to drive a 2-inch, inside diameter sampler 12 inches.

7/18 — Indicates the groundwater table and the date that the measurement was taken

Notes

1. Borings were performed July 12, 2013 with four-inch diameter, continuous flight power augers.

2. Boring logs shown in this report are subject to the limitations, explanations and conclusions of the report.

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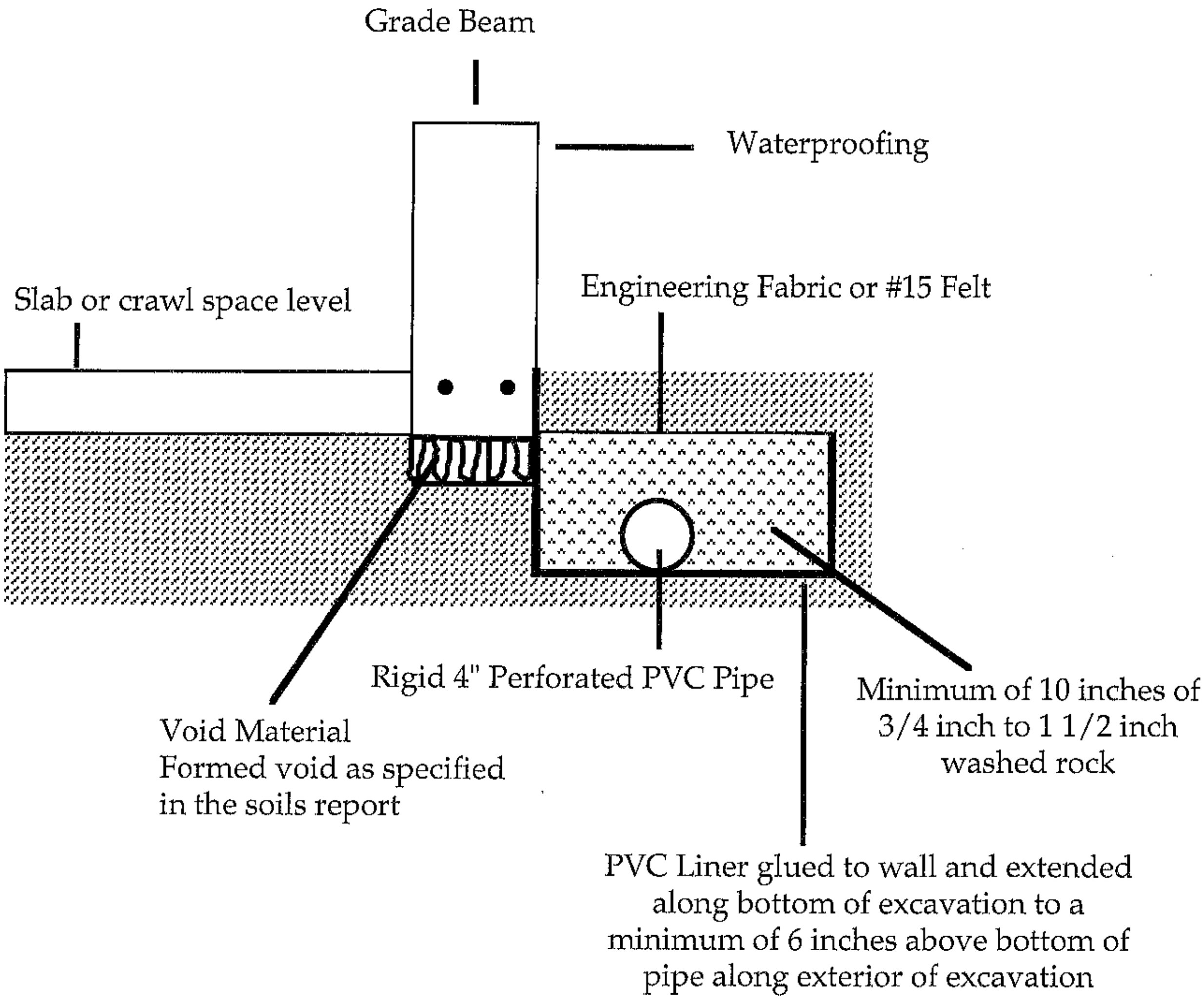
Typical Perimeter Drain Installation Drilled Pier Foundation System



Notes:

1. **Slope drain and pipe at a minimum of 1/8 inch per foot to suitable outfall (sump pit or daylight outfall).**

2. **Glue all vertical T's and standpipes.**

3. **Install non-perforated pipe from perimeter pipe into sump pit.**

Figure 3

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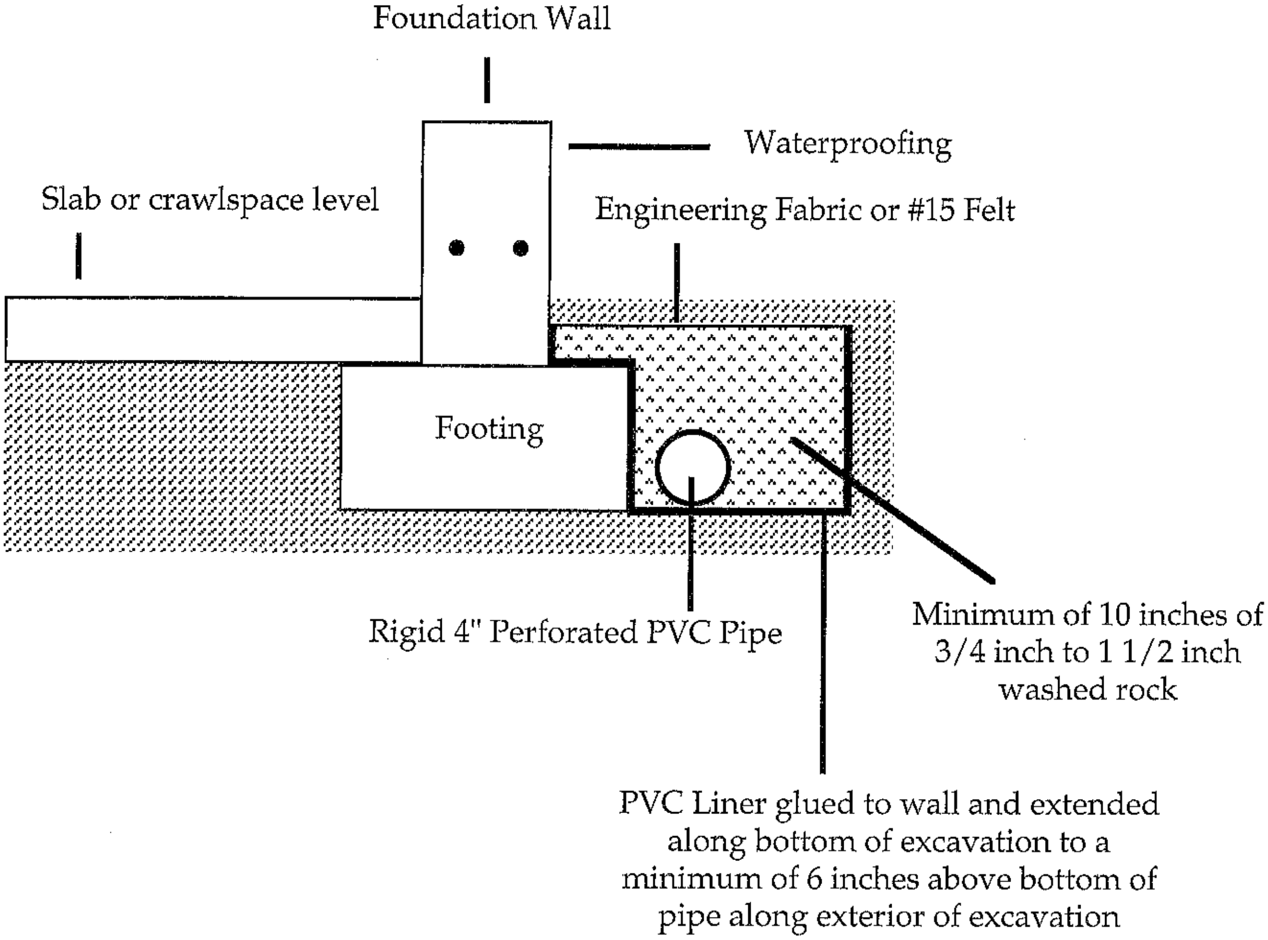
Typical Perimeter Drain Installation
Footing Foundation System



Notes:

1. **Slope drain and pipe at a minimum of 1/8 inch per foot to suitable outfall (sump pit or daylight outfall).**

2. **Glue all vertical T's and standpipes.**

3. **Install non-perforated pipe from perimeter pipe into sump pit.**

Figure 4

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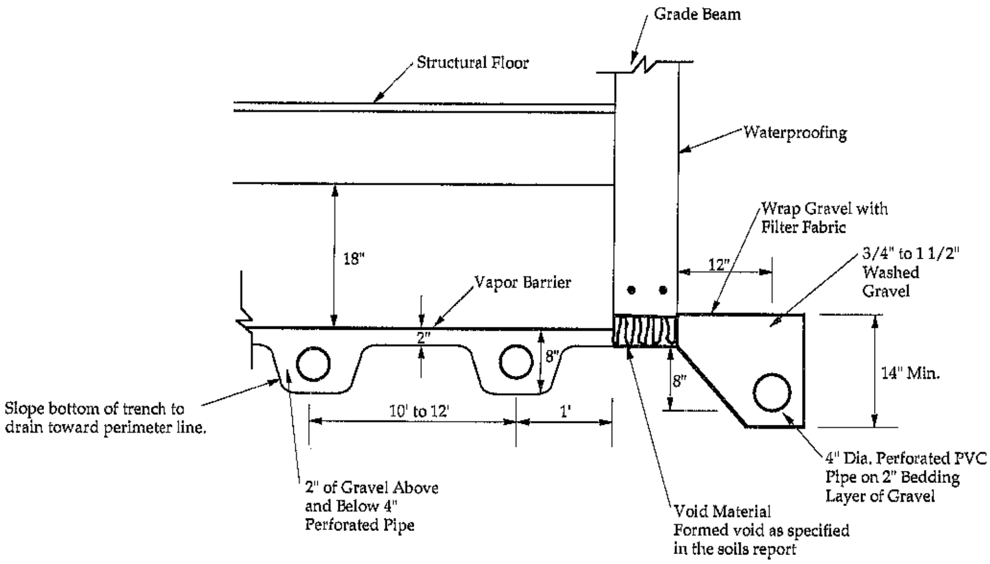
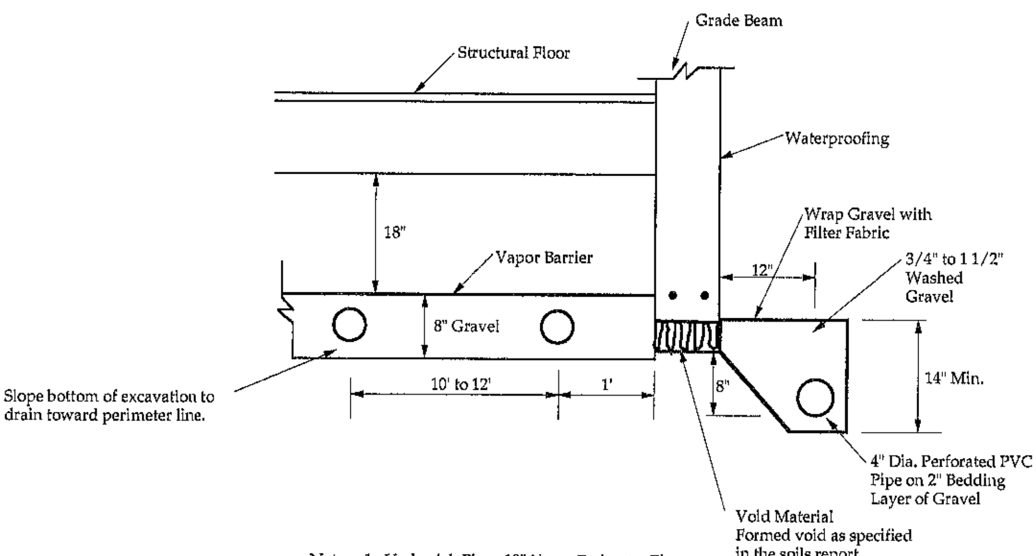
Typical Perimeter and Subfloor Drain System
Drilled Pier Foundation System for Structural Floors



Note: 1. Underslab Pipes 4"Above Perimeter Pipes.
2. Gravel for Perimeter Drain to Extend from Foundation Wall to Side of Excavation.
3. A washed gravel should be used for the backfill adjacent to the foundation walls, from the top of the perimeter drain up to the seasonal high groundwater level.

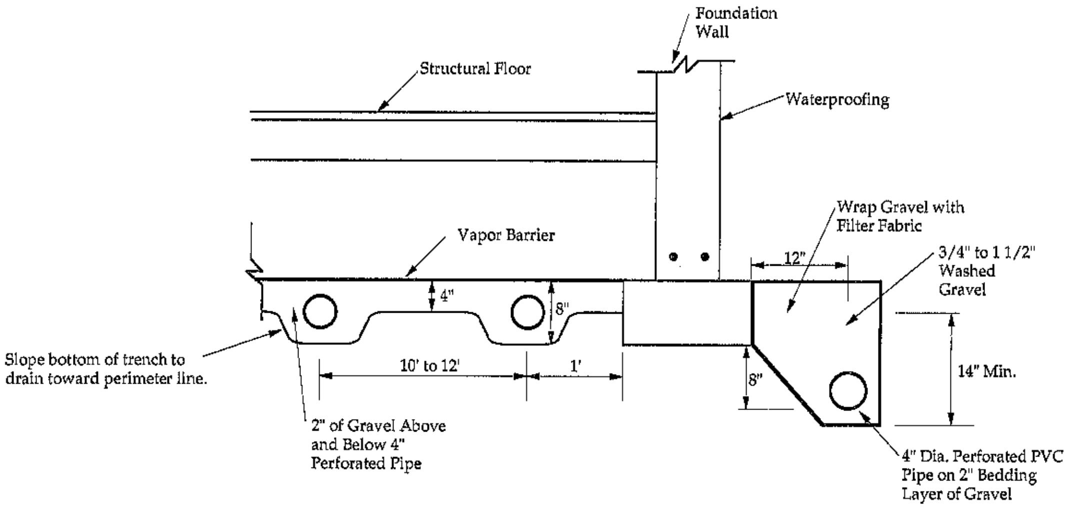
OPTION



Note: 1. Underslab Pipes 10"Above Perimeter Pipes.
2. Gravel for Perimeter Drain to Extend from Foundation Wall to Side of Excavation.
3. A washed gravel should be used for the backfill adjacent to the foundation walls, from the top of the perimeter drain up to the seasonal high groundwater level.

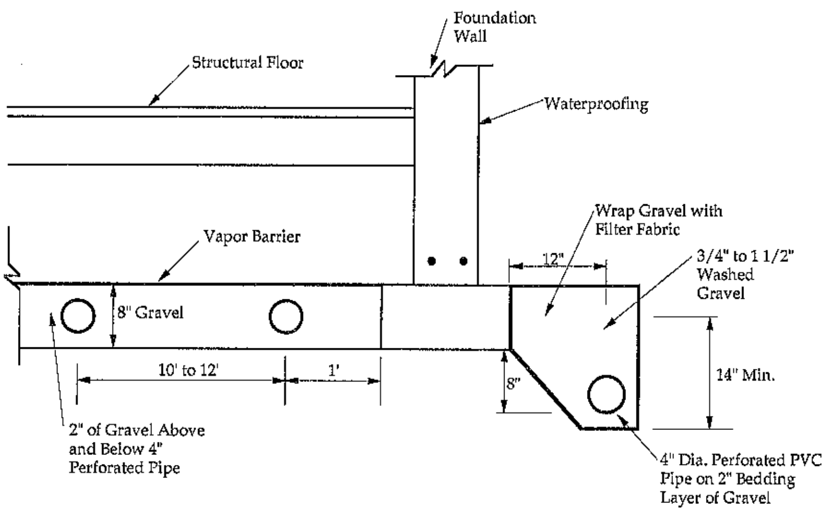
Figure 5

Typical Perimeter and Subfloor Drain System Footing Foundation System for Structural Floors



Note:
1. Underslab Pipes 10"Above Perimeter Pipes.
2. Gravel for Perimeter Drain to Extend from Foundation Wall to Side of Excavation.
3. A washed gravel should be used for the backfill adjacent to the foundation walls, from the top of the perimeter drain up to the seasonal high groundwater level.

OPTION



Note:
1. Underslab Pipes 10"Above Perimeter Pipes.
2. Gravel for Perimeter Drain to Extend from Foundation Wall to Side of Excavation.
3. A washed gravel should be used for the backfill adjacent to the foundation walls, from the top of the perimeter drain up to the seasonal high groundwater level.

Figure 6

Table 1
Summary of Soils Properties
Page 1/1
Project
13299S

PROPERTIES AT NATURAL MOISTURE CONTENT			**CONSOLIDATION/SWELL**				**DESCRIPTION**
Natural Moisture (%)	Natural Dry Density (PCF)	Unconfined Compression (PSF)	Loading (PSF)	Settlement (Dry) (%)	Settlement (Saturated) (%)	Swell (%)	
TH # 1 @ 4							
14.4	106.5	>9000	100	0.60	0.20		Fill - Mottled brown, very silty sand and clay with some gravel
			1000		1.30		
			2000		2.00		
0.4 % Swell upon the addition of water							

Appendix A
Soil Removal and Replacement Risk Analysis

An option to help mitigate or reduce slab movement is to remove and replace some of the expansive soils.

The basic concept is that sub-excavation of the expansive soils beneath the slabs or paving and replacement with suitable non-expansive materials is a method that might improve the performance of the slabs or paving. There is a relationship between the amount of material removed and the reduction of the risk. This relationship is non-linear and we consider it to be akin to a logarithmic curve with no significant risk reduction with less than 1 foot of removal and replacement and close to a 95% risk reduction with 10 feet of removal and replacement.

Therefore, we recommend that if a removal and replacement scenario is considered, that no less than 1 foot of removal and replacement be done. We anticipate that this reduces the risk by about 10% (the risk of movement being defined as the total vertical movement anticipated). The removal and replacement provides an additional benefit in that a buffer between the expansive soils and the pavement provides for moderation of the movement over a larger area. The total magnitude of the movement may be the same, but will be spread out over a larger area, which may cause less of the immediate differential cracking and heaving type of damage, which is usually associated with expansive soils.

Therefore, we summarize the risk reduction as follows:

1′ of removal and replacement	10% reduction in risk
2.5′ of removal and replacement	35% reduction in risk
5′ of removal and replacement	70% reduction in risk
7.5′ of removal and replacement	90% reduction in risk
10′ removal and replacement	95% reduction in risk

There are other factors that tend to make these values somewhat subjective. Clayey soils, such as those at this site, are very impermeable. Any non-expansive replacement soils will have permeabilities several orders of magnitude higher than the natural site soils. Therefore, water is much more easily transported through these soils. Any areas of poor grading and drainage may result in a more widespread problem than if no removal and replacement was done. Additionally, digging out an area can be analogous to digging a bathtub as there is no way for water to escape a depression that is dug and refilled with granular soils. We have seen this result in massive saturation of the soils beneath the replacement materials, resulting in very damaging heaving, essentially defeating the entire removal and replacement scheme.

There are a number of other possible scenarios to help reduce the effects of the expansive potential of the clay soils such as chemical stabilization or moisture stabilization schemes. Chemical stabilization generally requires the mixing of either flyash, cement, lime, or other chemical into the subgrade soils for a specified depth to reduce or almost eliminate the expansion potential of the clay particles however this is only good for the depth of treatment similar to the removal and replacement as outlined above. Another method would be moisture conditioning which requires the mixture of water to the clay soils and re-compacting them generally from 1 to 3 percent above optimum moisture content. Moisture conditioning is also limited to the depth of the treatment and is also subject to problems with proper mixing of the soil and water (i.e. dry areas and wet areas) and when the clay soils are above optimum moisture content tend to pump excessively and are difficult to compact.